Rethinking Human Error Statistics in Aircraft Accidents

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It seems like every time I read an aviation safety-related research study there is a ubiquitous statistic that always grabs my attention. I am referring to the "70%-80% of airplane accidents are attributable to human error" statistic. This stat grabs my attention not because of its seemingly high estimate; in fact, it surprises me that it is unrealistically low. It might be time to start acknowledging that almost *every* airplane accident has a human error component. I posit that 95%-99% of airplane accidents are attributable to human error. My statistical estimate is based on facts which will be discussed shortly.

Airplanes are so reliable and safe these days that in almost every case it is human error that begins, contributes to, or ends an accident sequence. The reason why I do not go as far as to say that 100% of accidents are caused by human error is because there are a few exceptions. The most recent example of this would be the Airbus A-320 that was ditched successfully in New York's Hudson River. The ditching was initiated due to a bird strike which caused both engines to flame out. In this particular case there was no human error. In fact, through Captain Sullenberger's heroic acts and superior airmanship, there were no lives lost and only minor injuries. This accident, however, is the exception and not the norm. Most other accidents are the concatenation of human errors.

To exemplify the point, I set out to conduct an informal study to investigate the contributing factors in a sample of airplane accidents. While not a true scientific study, the sample drawn was a fairly good representation of overall accident causes and provides enough meaningful data for the reader to draw his or her own conclusions. The study used the following data and methodology:

1. The National Transportation Safety Board (NTSB) aviation accident database was used to provide factual data.
2. The sample consisted of all Major Investigations conducted by the NTSB for the 10 year period 2000-2009.
3. All Major Investigations in the sample had at least one fatality and ranged from private aircraft to large air carriers.
4. There were a total of 29 accidents.
5. Three of the most recent accidents did not have a Probable Cause issued as of the date of this writing. However, preliminary data, where available, were used to determine whether human error may have caused, or contributed to, the accident. Four accidents were acts of terrorism and were excluded.
6. Twenty three accidents were usable for this study.
7. The accidents were additionally categorized as;
    a. No Anomalies (nothing technically wrong with the aircraft), or
    b. XXXX Malfunction (something technically wrong with the aircraft).

Results and Discussion

The results appear to support my soft hypothesis that the majority of aircraft accidents are due to human error. Out of the total of 23 usable accidents, each one had a human error component (or components). In fact, none of the accidents were caused by an aircraft malfunction due to reliability or airworthiness issues not propagated by an erroneous human intervention. Refer to the table below.

Total number of accidents in data set	29
Total usable accidents in data set	23 (79%)
Total number of accidents with no aircraft malfunctions	19 (83%)
Total number of accidents with aircraft malfunctions	4 (17%)
Total number of accidents caused by an aircraft malfunction due to reliability or airworthiness issues not propagated by an erroneous human intervention	0 (0%)
Total number of accidents caused by human error	**23 (100%)**

See complete data table at the end of this paper

For clarity I am going to provide some additional information regarding the way the data were categorized in the table. Accidents that were excluded were done so due to the fact that those accidents did not yet have a Probable Cause issued by the NTSB or they were acts of terrorism. The remaining accidents were decomposed into two broad categories; (a) those accidents with *no aircraft malfunctions*, and (b) those accidents *with aircraft malfunctions*. The distinction between these categories is important because, as the results indicate, the majority of accidents occurred when there was absolutely nothing wrong with the aircraft. On the other hand it should be pointed out that in the accidents that did occur where there was a malfunction onboard the aircraft, the pilots should have either been able to regain control of the aircraft—or—the pilots were unable to regain control of the aircraft due to a maintenance error. If this is the case, then although technically there was nothing the pilots could have done to recover the aircraft, there were still human errors propagated by the maintenance crew which eventually manifested into an unrecoverable airborne malfunction.

The results indicated that in each of the usable accidents human error was a primary factor. Thus 100% of this sample of accidents could be considered to have been caused by human error, whether by maintenance activities or in the operation of the aircraft. Maintenance errors tend to be more distal (a delay between the error and the actual accident) whereas operational errors tend to be more proximal (happen very quickly as a result of poor judgment or decisions by pilots). In either case there was some erroneous human action that precipitated the events leading up to the accident.

There was one major limitation to this informal study; there was a very small sample drawn from the NTSB database. Time constraints did not allow for a larger sample. Thus if other clusters of accidents were analyzed (say all accidents for the year 2005) the results may differ somewhat. However, in this particular study it was shown that 100% of the accidents had a human error component. In another, larger sample, it is likely that the rate would be somewhat less than this figure but probably not by much. The figure would most likely remain in the 95%-99% range that I proposed at the beginning of this article.

Summary and Recommendations

With some relevant data to support the theory that almost 100% of aircraft accidents are attributable to human error the next logical question would be what can be done to reduce this statistic? Indeed, this is a tricky question. Consider the fact that in the last century of powered flight we have been able to significantly reduce the amount of aircraft accidents attributable to pure mechanical/technical causes to nearly zero. On the other hand, accidents attributed purely to human error have grown exponentially and continue to be one of the last remaining impediments to realizing a near-zero accident rate. Speaking of accident rates, one should understand the potential limitations of the statistics used in this article. Let's say that in a certain year there were 10 commercial airline accidents and each was caused by human error. Twenty years later a study is conducted that shows that there was a significant reduction in commercial airline accidents (just one for the whole year compared to the previous ten). This would indicate a 90% decrease in accidents over time; however the one accident that did occur was due to human error. Thus, even though the rate decreased to just one accident, that one accident was caused by human error and therefore, for that year, each accident (1) was attributable to human error (100%).

The hard truth is that human error can never be completely eradicated and statistics will continue to point towards human performance deficiencies in the events that lead up to aircraft accidents. A maxim that I like to profess is, "To err is human but to recognize and recover is divine." This acknowledges that as long as there are humans involved in the operation of an aircraft there will always be plenty of opportunities for error. It should not be construed that this makes it acceptable to commit an error. It means that as long as we acknowledge that erroneous actions are inherently human we should take steps to mitigate the impact of errors should they occur. The difference between an accident that happened and one that did not is not just luck. In the accident that happened there was a chain of events that managed to breach the system's built-in defenses. These defenses included such things as regulations, policies, training transfer, operating specifications, task cards, and the use of standard operating procedures.

Countermeasures are being deployed and so far they seem to be having a positive effect. From an organizational standpoint we are seeing a considerable increase in "soft skills" training courses worldwide (depending on your location some courses may be mandatory while others are highly recommended by your regulator). These soft skills awareness courses specifically focus on human performance issues and error reduction strategies. Human factors (HF), crew resource management (CRM), and threat and error management (TEM) are examples of these types of courses. Additionally, a safety management system (SMS) will help to provide a "central safety hub" for human performance issues with the added benefit of high-level management accountability.

On an individual level I believe that we are making good progress in increasing our awareness of the fact that we, as humans, can and do commit errors. Hopefully, with this knowledge, there will be that little extra attention to detail, that one extra look before closing it up, or the prudent decision to go-around when confronted with an unstabilized approach. On the other hand we also need to understand that there will always be organizational and cultural influences that may cause an otherwise rational aircraft maintenance technician or pilot to do something he or she would not normally do, usually due to the confluence of pressure, unrealistic deadlines, and stress. Needless to say, there can be a very fine line between being a company person doing whatever it takes to get the job done and a being a rational, expert decision maker who is fully aware of the inherent risks of pushing the safety envelope.

In closing, we do need to understand that although most aircraft accidents are due to some form of human error, aviation is still by far the safest mode of transportation. Yet, each time we read an accident report we tend to see the same types of recurring causal factors; unprofessional behavior, deviations from standard operating procedures or maintenance manuals, skipped steps, improper decisions, poor judgment, etc. These factors are typically compounded by fatigue (which is a complex issue and may be propagated at both the regulatory and organizational levels as well as at the individual level).

Remember that although human error may be inevitable, it still does not make it acceptable. You may be the last line of defense in deflecting the error trajectory that results in a serious accident. Always maintain situation awareness (know your surroundings and status of tasks). Think about your actions and their corresponding safety implications (will what I do compromise the safety of the aircraft and passengers?). Remember that just because everyone else is doing it that doesn't always make it right (i.e., skipping functional or operational checks or not using the checklist). Always be a true professional and abide by the regulations (i.e., no non-essential chatter when the sterile cockpit rule is in effect). I could go on and on but I think you get the point.

Modern day aircraft are highly reliable machines that come from the factory ready to give many years of safe, reliable transportation. It is only when the human gets involved with the maintenance or operation of the aircraft do we start to see the types of recurring accidents that are posted every day to the NTSB website. With a concerted effort we can continue to diminish the accidents attributable to human error and make flying even safer, both now and in the future. Since you are the human, *you can* make the difference!

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Accident Details and Probable Cause (NTSB Verbatim Data)	Aircraft Technical Condition	Author Comments
2/12/2009: Bombardier DHC-8 (50 fatalities) The National Transportation Safety Board determines that the probable cause of this accident was the captain's inappropriate response to the activation of the stick shaker, which led to an aerodynamic stall from which the airplane did not recover. Contributing to the accident were (1) the flight crew's failure to monitor airspeed in relation to the rising position of the low-speed cue, (2) the flight crew's failure to adhere to sterile cockpit procedures, (3) the captain's failure to effectively manage the flight, and (4) Colgan Air's inadequate procedures for airspeed selection and management during approaches in icing conditions.	No Anomalies	Nothing was technically wrong with the aircraft. However, a series of **human errors** contributed to this accident.
9/19/2009: Learjet 60 (4 fatalities) Probable cause not issued as of this writing.	Gear/Tire Malfunction	Excluded from results (however, current evidence suggests that the pilots should have continued the takeoff rather than aborting past takeoff decision speed (V1).
7/31/2008: Raytheon BAE 125 (8 fatalities) Probable cause not issued as of this writing.	Pending Report	Excluded from results. No data available.
10/11/2006: Cirrus SR-20 (2 fatalities) The pilots' inadequate planning, judgment, and airmanship in the performance of a 180º turn maneuver inside of a limited turning space.	No Anomalies	Nothing was technically wrong with the aircraft. However, a series of **human errors** contributed to this accident.
8/27/2006: Bombardier CRJ-100 (49 fatalities) The flight crewmember's failure to use available cues and aids to identify the airplane's location on the airport surface during taxi and their failure to cross-check and verify that the airplane was on the correct runway before takeoff. Contributing to the accident were the flight crew's nonpertinent conversation during taxi, which resulted in a loss of positional awareness, and the Federal Aviation Administration's failure to require that all runway crossings be authorized only by specific air traffic control clearances.	No Anomalies	Nothing was technically wrong with the aircraft. However, a series of **human errors** contributed to this accident.

12/19/2005: Grumman G-73T (20 fatalities) The in-flight failure and separation of the right wing during normal flight, which resulted from (1) the failure of the Chalk's Ocean Airways maintenance program to identify and properly repair fatigue cracks in the right wing and (2) the failure of the Federal Aviation Administration to detect and correct deficiencies in the company's maintenance program.	Structural Malfunction	The pilots were unable to recover the aircraft in flight due to a structural malfunction. The malfunction was precipitated by **human errors** in maintenance procedures which included skipped inspections and carelessness in maintaining a 60+ year old aircraft. The NTSB also described in its accident report a "sloppy corporate culture."
12/8/2005: Boeing 737-700 (1 fatality) The pilots' failure to use available reverse thrust in a timely manner to safely slow or stop the airplane after landing, which resulted in a runway overrun. This failure occurred because the pilots' first experience and lack of familiarity with the airplane's autobrake system distracted them from thrust reverser usage during the challenging landing. Contributing to the accident were Southwest Airline's 1) failure to provide its pilots with clear and consistent guidance and training regarding company policies and procedures related to arrival landing distance calculations; 2) programming and design of its onboard performance computer, which did not present inherent assumptions in the program critical to pilot decision making; 3) plan to implement new autobrake procedures without a familiarization period; and 4) failure to include a margin of safety in the arrival assessment to account for operational uncertainties. Also contributing to the accident was the pilots' failure to divert to another airport given reports that included poor braking action and a tailwind component greater than 5 knots. Contributing to the severity of the accident was the absence of an engineering materials arresting system, which was needed because of the limited runway safety area beyond the departure end of runway 31C.	No Anomalies	Nothing was technically wrong with the aircraft. However, a series of **human errors** contributed to this accident.
6/7/2005: Embraer 170 (1 fatality) The inexperience of the driver (fleet service agent) in the operation of a belt loader, which resulted in the belt loader being driven under, and colliding with, the airplane.	No Anomalies	Nothing was technically wrong with the aircraft or belt loader. However, a series of **human errors** contributed to this accident.

2/16/2005: Cessna 560 (8 fatalities) The flight crew's failure to effectively monitor and maintain airspeed and comply with procedures for deice boot activation on the approach, which caused an aerodynamic stall from which they did not recover. Contributing to the accident was the Federal Aviation Administration's failure to establish adequate certification requirements for flight into icing conditions, which led to the inadequate stall warning margin provided by the airplane's stall warning system.	No Anomalies	Nothing was technically wrong with the aircraft. However, a series of **human errors** contributed to this accident.
11/22/2004: Gulfstream G-III (3 fatalities) The flight crew's failure to adequately monitor and cross check the flight instruments during the approach. Contributing to the accident was the flight crew's failure to select the instrument landing system frequency in a timely manner and to adhere to approved company approach procedures, including the stabilized approach criteria.	No Anomalies	Nothing was technically wrong with the aircraft. However, a series of **human errors** contributed to this accident.
10/19/2004: BAE Jetstream 32 (13 fatalities) The pilots' failure to follow established procedures and properly conduct a nonprecision instrument approach at night in IMC, including their descent below the minimum descent altitude (MDA) before required visual cues were available (which continued unmoderated until the airplane struck the trees) and their failure to adhere to the established division of duties between the flying and nonflying (monitoring) pilot. Contributing to the accident was the pilots' failure to make standard callouts and the current Federal Aviation Regulations that allow pilots to descend below the MDA into a region in which safe obstacle clearance is not assured based upon seeing only the airport approach lights. The pilots' unprofessional behavior during the flight and their fatigue likely contributed to their degraded performance.	No Anomalies	Nothing was technically wrong with the aircraft. However, a series of **human errors** contributed to this accident.

10/14/2004: Canadair CL-600 (2 fatalities) (1) The pilots' unprofessional behavior, deviation from standard operating procedures, and poor airmanship, which resulted in an in-flight emergency from which they were unable to recover, in part because of the pilots' inadequate training; (2) the pilots' failure to prepare for an emergency landing in a timely manner, including communicating with air traffic controllers immediately after the emergency about the loss of both engines and the availability of landing sites; and (3) the pilots' improper management of the double engine failure checklist, which allowed the engine cores to stop rotating and resulted in the core lock engine condition. Contributing to this accident were (1) the core lock engine condition, which prevented at least one engine from being restarted, and (2) the airplane flight manuals that did not communicate to pilots the importance of maintaining a minimum airspeed to keep the engine cores rotating.	No Anomalies	Nothing was technically wrong with the aircraft. However, a series of **human errors** contributed to this accident.
8/13/2004: Convair CV-340 (1 fatality) Fuel starvation resulting from the captain's decision not to follow approved fuel crossfeed procedures. Contributing to the accident were the captain's inadequate preflight planning, his subsequent distraction during the flight, and his late initiation of the in-range checklist. Further contributing to the accident was the flight crew's failure to monitor the fuel gauges and to recognize that the airplane's changing handling characteristics were caused by a fuel imbalance.	No Anomalies	Nothing was technically wrong with the aircraft. However, a series of **human errors** contributed to this accident.
3/23/2004: Sikorsky S76A (10 fatalities) The flight crew's failure to identify and arrest the helicopter's descent for undetermined reasons, which resulted in controlled flight into terrain.	No Anomalies	Nothing was technically wrong with the aircraft. However, a series of **human errors** contributed to this accident.

1/8/2003: Beech 1900D (21 fatalities) The airplane's loss of pitch control during take-off. The loss of pitch control resulted from the incorrect rigging of the elevator system compounded by the airplane's aft center of gravity, which was substantially aft of the certified aft limit. Contributing to the cause of the accident were (1) Air Midwest's lack of oversight of the work being performed at the Huntington, West Virginia, maintenance station; (2) Air Midwest's maintenance procedures and documentation; (3) Air Midwest's weight and balance program at the time of the accident; (4) the Raytheon Aerospace quality assurance inspector's failure to detect the incorrect rigging of the elevator control system; (5) the Federal Aviation Administration's (FAA) average weight assumptions in its weight and balance program guidance at the time of the accident; and (6) the FAA's lack of oversight of Air Midwest's maintenance program and its weight and balance program.	Flight Control Malfunction	The pilots were unable to recover the aircraft in flight due to a flight control malfunction. The malfunction was precipitated by **human errors** in maintenance procedures which were compounded by an improperly loaded aircraft.
10/25/2002: Beech King Air 100 (8 fatalities) The flight crew's failure to maintain adequate airspeed, which led to an aerodynamic stall from which they did not recover.	No Anomalies	Nothing was technically wrong with the aircraft. However, a series of **human errors** contributed to this accident.
11/12/2001: Airbus A300 (265 fatalities) The in-flight separation of the vertical stabilizer as a result of the loads beyond ultimate design that were created by the first officer's unnecessary and excessive rudder pedal inputs. Contributing to these rudder pedal inputs were characteristics of the Airbus A300-600 rudder system design and elements of the American Airlines Advanced Aircraft Maneuvering Program.	No Anomalies	Nothing was technically wrong with the aircraft. However, a series of **human errors** contributed to this accident.
10/10/2001: Cessna 208 (10 fatalities) An in-flight loss of control resulting from upper surface ice contamination that the pilot-in-command failed to detect during his preflight inspection of the airplane. Contributing to the accident was the lack of a preflight inspection requirement for CE-208 pilots to examine at close range the upper surface of the wing for ice contamination when ground icing conditions exist.	No Anomalies	Nothing was technically wrong with the aircraft. However, a series of **human errors** contributed to this accident.

9/11/2001: Boeing 767 (92 fatalities) **9/11/2001: Boeing 757 (64 fatalities)** **9/11/2001: Boeing 767 (65 fatalities)** **9/11/2001: Boeing 757 (44 fatalities)**	Terrorism Terrorism Terrorism Terrorism	Excluded from results Excluded from results Excluded from results Excluded from results
8/5/2001: deHavilland Dash 8 (1 fatality) The ramp agent's impaired performance due to his hyperthyroidism, which was exacerbated by the heat and was inadequately controlled by medication, and possibly also due to the use of an antianxiety medication.	No Anomalies	Nothing was technically wrong with the aircraft. However, a series of **human errors** contributed to this accident. An employee was fatally struck by the right propeller blades of the aircraft. It was the employee's first day working at DCA and his first day back at work from extended leave.
3/29/2001: Gulfstream G-III (18 fatalities) The flight crew's operation of the airplane below the minimum descent altitude without an appropriate visual reference for the runway. Contributing to the cause of the accident were the Federal Aviation Administration's (FAA) unclear wording of the March 27, 2001, Notice to Airmen regarding the nighttime restriction for the VOR/DME-C approach to the airport and the FAA's failure to communicate this restriction to the Aspen tower; the inability of the flight crew to adequately see the mountainous terrain because of the darkness and the weather conditions; and the pressure on the captain to land from the charter customer and because of the airplane's delayed departure and the airport's nighttime landing restriction.	No Anomalies	Nothing was technically wrong with the aircraft. However, a series of **human errors** contributed to this accident.
1/27/2001: Beech 200 (10 fatalities) The pilot’s spatial disorientation resulting from his failure to maintain positive manual control of the airplane with the available flight instrumentation. Contributing to the cause of the accident was the loss of a.c. electrical power during instrument meteorological conditions.	Electrical Malfunction	The pilot was unable to maintain control of the aircraft in flight due to an electrical malfunction. However, there was enough instrumentation available to control the aircraft. **Human error**.
8/9/2000: Piper PA-31 (11 fatalities) The failure of the pilots of the two airplanes to see and avoid each other and maintain proper airspace separation during visual flight rules flight.	No Anomalies	Nothing was technically wrong with the aircraft. However, a series of **human errors** contributed to this accident.
8/9/2000: Piper PA-44 (11 fatalities) The failure of the pilots of the two airplanes to see and avoid each other and maintain proper airspace separation during visual flight rules flight.	No Anomalies	Nothing was technically wrong with the aircraft. However, a series of **human errors** contributed to this accident.

5/21/2000: BAE Jetstream 31 (19 fatalities) The flight crew's failure to ensure an adequate fuel supply for the flight, which led to the stoppage of the right engine due to fuel exhaustion and the intermittent stoppage of the left engine due to fuel starvation. Contributing to the accident were the flight crew's failure to monitor the airplane's fuel state and the flight crew's failure to maintain directional control after the initial engine stoppage.	No Anomalies	Nothing was technically wrong with the aircraft. However, a series of **human errors** contributed to this accident.
2/16/2000: Douglas DC-8 (3 fatalities) A loss of pitch control resulting from the disconnection of the right elevator control tab. The disconnection was caused by the failure to properly secure and inspect the attachment bolt.	Flight Control Malfunction	The pilots were unable to recover the aircraft in flight due to a flight control malfunction. The malfunction was precipitated by **human errors** in maintenance procedures.